NATIONAL BUREAU OF STANDARDS REPORT

5839

PERFORMANCE TESTS OF A SMITH "LIFETIME"
INPINGEMENT TYPE AIR FILTER

by

Thomas W. Watson and Henry E. Robinson

Report to
General Services Administration
Public Buildings Service
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Heat Transfer Section
Building Technology Division

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1. INTRODUCTION*

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a cleanable impingement type air filter were determined to provide information to assist in the preparation of new air filter specifications.

The test results presented herein were obtained on a specimen filter submitted by its manufacturer at the request of the Public Buildings Service and included determinations of dust-arresting efficiency with two aerosols (atmospheric air and Cottrell precipitate), pressure drop, dirt load performance characteristics, and cleanability of the specimen.

2. DESCRIPTION OF THE FILTER SPECIMEN

The filter was manufactured by the Smith Filter Corporation, Moline, Illinois, and was of the cleanable viscid type, 20 by 20 by 2 inches in nominal size. It was identified by nameplate as a Smith "Lifetime" air filter. The filtering media was composed of successive layers of vee-crimped expanded aluminum sheet arranged, with the vees of adjacent sheets at right angles, as follows, starting at the upstream face: one layer expanded metal 3/4 by 1/4 mesh; eight layers EM 5/16 by 1/8 mesh. The layers of media were compressed to a thickness of about two inches and surrounded at the edges by an aluminum frame. The filter had actual outside dimensions of 20 by 20 by 2 inches, leaving a free opening 18 1/4 inches square (2.31 $ft.^2$ net face area), and weighed 4.4 lb. when clean and oiled.

The manufacturer submitted an adhesive designated as "S-2 Filter Oil" for oiling the filter. This was done in preparation for the test by spraying the filter faces with the oil and letting the excess fluid drain off with the filter standing on edge with one corner low for 19 hours prior to the test.

*This report is submitted for information only, and is not released for use in connection with advertising or sales promotion.

3. TEST METHOD AND PROCEDURE

Efficiency determinations were made by the NBS "Dust-Spot" method using the following aerosols: (a) outdoor atmospheric air drawn through the laboratory without addition of other dust or contaminant; and (b) Cottrell precipitate, dispersed in the outdoor atmospheric air. The test method is described in the paper "A Test Method for Air Filters" by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938). In conducting the tests air was sampled from the test duct at equal rates, from points one foot upstream and eight feet downstream of the filter, and passed through known areas of Whatman No. 41 filter paper. The areas of the filter papers used upstream and downstream, or the times during which the air was sampled upstream and downstream, were selected experimentally so that the change in transmission of light through the two filter paper spots would be about the same. The filter efficiency was calculated by means of the formula

$$\text{Efficiency, percent} = 100 \left[1 - \frac{A_2}{A_1} \cdot \frac{O_2}{O_1} \cdot \frac{T_1}{T_2} \right]$$

where A represents the dust spot area, O the change in light transmittance of the filter paper as measured before and after the deposition of dust, and T the time during which the air sample was drawn. Subscripts 1 and 2 refer to the upstream and downstream positions, respectively.

Two efficiency-measuring techniques, or modifications based on the above formula were used, depending on the apparent efficiency of the filter with the different aerosols. For the tests made, techniques M and N were used, as indicated in Table 2.

All light transmission measurements were made with the photometer illumination at a constant intensity, as determined by measurements on a reference of constant transmission characteristics. The filter papers used upstream and downstream were selected to have equal light transmissions when clean.

The efficiency of the filter in arresting particulate matter in atmospheric air was determined by means of two tests of the M type, as described above, with the filter clean. Following these, the efficiency of the filter in arresting Cottrell precipitate was measured by means of the N-type tests, after which was begun the process of loading the filter with a mixture of 4 percent of cotton lint and

96 percent of Cottrell precipitate, by weight, separately dispersed in the air stream. The lint used for this purpose was No. 7 cotton linters previously ground in a Wiley mill with a 4-millimeter screen. At suitable periods as loading progressed, the efficiency of the filter was determined using Cottrell precipitate in outdoor air. The pressure drop was recorded at intervals during the test. The dirt-loading was continued until the pressure drop increased to approximately 0.50 inch W.G. The efficiency was again determined with Cottrell precipitate and then with atmospheric air as the aerosols.

The filter was then removed from the test duct and cleaned by means of a stream of cold water from a high pressure hose nozzle, directed at and into the filter media.

After being dried, the filter was reoiled by spraying and, after draining approximately 20 hours, was reinstalled in the test duct for pressure drop measurements at various air flows.

4. TEST RESULTS

Table 1 presents data as to the pressure drop, at several rates of air flow, of the clean and oiled filter, and also of the same filter after it had been loaded with dirt, cleaned, and reoiled.

The performance of the filter at 800 cfm is summarized in Table 2, for both aerosols A and C. The performance of the filter in regard to aerosol C (Cottrell precipitate in atmospheric air) is also shown graphically in Figure 1. The efficiency of the filter in arresting aerosol A (atmospheric particulate matter), both initially, and after its resistance had been increased to 0.5 inch W.G., is indicated in Table 2.

Observation of the filter at the end of the dirt-loading test revealed that the greater part of the arrested dust and lint was found on the upstream face and had not penetrated the media beyond a depth of about one inch. The downstream face of the media was slightly darkened with dust at the end of the loading test.

The pressure drops recorded in Table 1 indicate that, after the filter had been subjected to loading with the dust-lint mixture and had been cleaned and reoiled, its pressure drop at 800 cfm was substantially the same. It is believed that the filter can be considered as satisfactorily cleanable.

After the unit had been removed from the test duct, the section of the duct 5 feet long downstream of the unit, and upstream of a 3/4 inch thick wood strip fastened flat across the bottom of the test duct, was carefully swept out with a fine brush. The amount of material obtained from the duct by this sweeping was 11.5 grams, or 2.0 percent of the dust load reaching the filter, constituting the fall-out in the first 5 feet of the duct from the air passed through the filter, and consisting for the most part of large dust particles with some visible lint.

Cellophane tapes, stretched across the test duct downstream of the filter with the adhesive side facing upstream, indicated upon visual and microscopic examination after exposure to the air stream that large numbers of particles of sizes up to approximately 200 microns, and some lint, had passed through the filter during the dirt-loading tests. Particles much smaller than 5 microns were observed in quantity by microscopic examination of the downstream filter papers obtained in tests with both aerosols.

TABLE 1

Pressure Drop of Clean Oiled Filter

Air Flow cfm	Face Velocity fpm	Pressure Drop (1) in. W.G.	Pressure Drop (2) in. W.G.
1200	520	0.170	0.176
1000	433	.121	.125
800	346	.077	.080
600	260	.047	.048

(1) Initial values for the clean oiled filter.

(2) Values for the filter after the dirt-loading test, cleaning operation, and reoiling.

TABLE 2

Performance of Filter at 800 CFM

Inlet Aerosol (1)	Total Dirt Load (2) grams	Pressure Drop in. W.G.	Eff. Meas. Technique (3)	Efficiency percent
A	-	0.077	M	11
	-	.077	M	3
C	7	.077	N	51
	14	.077	N	51
	22	.078	N	52
	50	.087	N	52
	265	.167	N	59
	340	.215	N	61
	396	.266	N	66
	489	.380	N	70
	571	.511	N	72
A	571	.511	M	28

(1) Aerosol A: Particulate matter in atmospheric air at NBS.
Aerosol C: Cottrell precipitate in atmospheric air (1 gram per 1000 cf).

(2) Average mixture: 4 percent lint, 96 percent Cottrell precipitate, by weight.

(3) Efficiency measuring technique:

M: Air sampled at equal rates through equal areas of filter paper for equal times.

N: Air sampled at equal rates for equal times; downstream area selected to obtain approximately equal dust-spot opacities upstream and downstream.

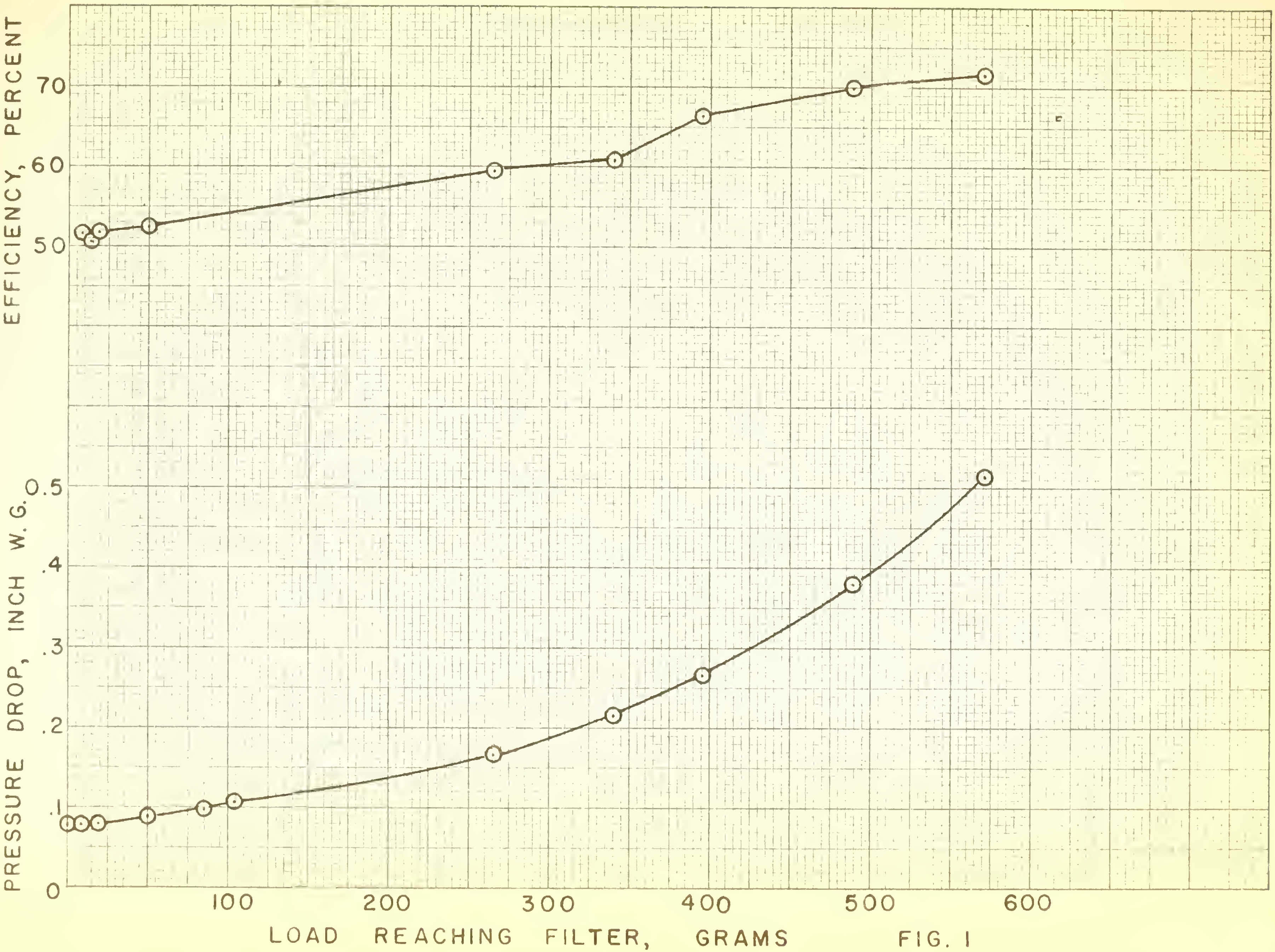
EFFICIENCY, PERCENT
70
60
50
PRESSURE DROP, INCH W. G.
0.5
.4
.3
.2
.1
0
100
200
300
400
500
600
LOAD REACHING FILTER, GRAMS

FIG. 1

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Sinclair Weeks, *Secretary*

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WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.
Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.
Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.
Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.
Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.
Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.
Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.
Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.
Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.
Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.
Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.
Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.
• Office of Basic Instrumentation. • Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.
Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research.
Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.
Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

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